Stellar Age Chronometers

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Abstract

Scientists use various methods to determine the age of stars such as radiometric, nuclear and spin down ages. These produce many ages that are impossible. Some have future ages showing the star does not exist in the present but in the future. Many give ages well in excess of the assumed 13.8-billion-year evolutionary age of the universe. There are many conflicting dates for the one star.

Introduction

A fifty-page article recently points that there is only one star whose age is accurately known: “There is exactly one stellar age that is both precise and accurate, that of the Sun, and it illustrates some of the inherent problems in determining ages. The Sun is 4,567 ± 5 million years old. The extraordinary precision of 1 million years represents measurement error (individual measurements are precise to 0.6 million years, 2002), and the only slightly larger systematic error of 5 million years is due to uncertainty over the precise sequence of events in the early years of the Solar System’s history. That systematic error should lessen as we understand those events better. This age is determined from the decay of radionuclides.” (Soderblom, 2010, P. 586)

This date is determined by radiometric dating which has been shown by creationists to have many inherent problems. According to the Big Bang theory the age of the Universe is 10 to 15 billion years.[1] Standard evolutionist publications give the age of the universe as 13.75 billion years. [2, 3]

Thorium and Uranium Chronometers

Research done in 2002 **(Schatz, 2002)** on the star CS 31082-001 has produced an array of dates [Table 1] between 300 million and 34 billion years old. Schatz claims that the stars age can be determined accurately: “Stellar elemental abundance observations of long-lived radioactive nuclear species synthesized in the r-process can be used to derive estimates for the ages and history of the underlying nucleosynthesis events.” **(Schatz, 2002, P. 626)** In another place he admits dates have appeared far older than the Big Bang: “The resulting age range for the r-process elements in CS 31082-001 is 9–18 Gyr.” **(Schatz, 2002, P. 627)** Another problem are negative or future ages **(Schatz, 2002, P. 635)** which are impossibly young. Dates as low as -8 billion years and -5.1 billion years have been obtained.

Table 1

Dating Method	Evolution Model	Mass Model	Age (Ga)	Error (Ga)	Max Age (Ga)	Min Age (Ga)
U/Th	Single	EFT	3.2	2.3	5.5	0.9
U	Single	EFT	2.3	1.8	4.1	0.5
Th	Single	EFT	0.3	5.7	6	-5.4
U/Th	Uniform	EFT	7.3	6.3	13.6	1
U	Uniform	EFT	5	4.2	9.2	0.8
Th	Uniform	EFT	1	11	12	-10
U/Th	Single	HFB	0.3	2.3	2.6	-2
U	Single	HFB	4.9	1.8	6.7	3.1
Th	Single	HFB	14.8	5.7	20.5	9.1
U/Th	Uniform	HFB	0.8	4.7	5.5	-3.9
U	Uniform	HFB	11	4.9	15.9	6.1
Th	Uniform	HFB	34	16	50	18
		Max Age	34	16	50	18
		Min Age	0.3	1.8	2.6	-10

(Schatz, 2002, P. 632)

Table 1 contains four negative dates [Red] and seven dates [Blue] older than the Big Bang [14 billion Years] explosion. There is a 60 billion age range between the smallest and oldest dates.

The author uses various unproved ‘assumptions’ to obtain dates. The author uses the word over 20 times. “While all our r-process models pass this important test, the large spread of the single-event ages from the HFBCS-1 calculations is a problem. Of course, we do not necessarily expect consistent single-event ages, as the entire history of Galactic chemical evolution is surely not characterized by a single burst of elemental enrichment.” **(Schatz, 2002, P. 632)** There are three age graphs **(Schatz, 2002, P. 635, 636)** in Schatz’s article. If we put them into Microsoft Paint we can use the pixel coordinates to workout the values of the data points.

Table 2

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	7.33	-10.12	17.44
2	8.55	-6.10	14.65
3	7.85	-8.72	16.57
4	9.59	-2.97	12.56
5	8.55	-6.45	15.00
6	8.90	-5.41	14.30
7	8.90	-4.71	13.60
8	9.07	-18.49	27.56
9	4.71	-5.93	10.64
10	8.72	1.05	7.67
11	10.81	-6.80	17.62
12	8.20	8.72	0.52
13	13.43	12.03	1.40
14	14.65	-0.35	15.00
Average	9.23	-3.87	13.18
Maximum	14.65	12.03	27.56
Minimum	4.71	-18.49	0.52
Difference	9.94	30.52	27.03

(Schatz, 2002, P. 635)

Table 2 contains eleven negative dates [Red] and one date older [Blue] than the Big Bang [14 billion Years] explosion. There is a 33 billion age range between the smallest and oldest dates.

Table 3

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	13.48	15.00	1.52
2	11.04	7.68	3.35
3	11.65	9.51	2.13
4	11.34	7.68	3.66
5	11.65	9.21	2.44
6	11.04	6.77	4.27
7	11.34	8.29	3.05
8	10.43	4.94	5.49
9	11.04	7.07	3.96
10	12.56	11.95	0.61
11	11.65	9.21	2.44
12	13.17	13.78	0.61
13	12.26	10.43	1.83
14	15.91	22.32	6.40
15	13.17	13.78	0.61
16	14.39	17.44	3.05
17	12.56	12.26	0.30
18	12.87	12.87	0.00
Average	12.31	11.12	2.54
Maximum	15.91	22.32	6.40
Minimum	10.43	4.94	0.00
Difference	5.49	17.38	6.40

(Schatz, 2002, P. 636)

Table 3 contains six dates older than the Big Bang explosion and a seventeen-billion-year age range. "However, the resulting U/X (weighted average 7:6 +/- 2:3 Ga), Th/X (weighted average -8:1 +/- 5:8 Ga), and U/Th (15:5 +/- 3:2 Ga) ages clearly do not agree with one another." **(Schatz, 2002, P. 634)**

Table 4

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	13.19	8.55	4.64
2	14.64	12.75	1.88
3	13.77	10.00	3.77
4	15.65	15.65	0.00
5	14.20	11.88	2.32
6	14.93	13.48	1.45
7	14.78	13.91	0.87
8	10.72	0.14	10.58
9	14.78	12.75	2.03
10	16.96	19.86	2.90
11	14.35	12.03	2.32
12	19.13	27.25	8.12
13	20.58	30.58	10.00
14	16.38	18.70	2.32
15	15.51	15.36	0.14
Average	15.30	14.86	0.44
Maximum	20.58	30.58	10.58
Minimum	10.72	0.14	0
Difference	9.86	30.72	10.58

(Schatz, 2002, P. 636)

Table 4 contains eighteen dates older than the Big Bang explosion and an age range of 30 billion years.

Dating of the Strongly r-process Enhanced Stars

Another star dated has an age range of 43.8 billion years. "Radioactive dating for CS 29491−069 with the observed thorium and rare-earth element abundance pairs results in an average age of 9.5 Gyr, when based on solar r-process residuals, and 17.6 Gyr, when using HEW model predictions. Chronometry seems to fail in the case of HE 1219−0312, resulting in a negative age due to its high thorium abundance." **(Hayek, 2009, Page 511)**

Fourteen dates are negative. Eleven dates are over 16 billion years old. CS 29491-069 has an age range of 43.8 billion years (-7.3 to 36.5 billion years old).

Table 5

Isotope	CS 29491-069	CS 29491-069	Age	HE 1219-0312	HE 1219-0312	Age
Ratios	Residual Age	HEW Age	Difference	Residual Age	HEW Age	Difference
Th/Ba	1.9	17.1	15.2	-6.5	8.7	15.2
Th/La	0.9	16.5	15.6	-5.7	9.9	15.6
Th/Ce	17.1	24.6	7.5	-0.6	6.8	7.4
Th/Pr	10.3	13.2	2.9	-6.5	-3.6	2.9
Th/Nd	10.5	13.4	2.9	-2.6	0.4	3
Th/Sm	12	11.8	-0.2	-0.1	-0.3	0.2
Th/Eu	3	3.8	0.8	-4.9	-4.1	0.8
Th/Gd	13.5	21.1	7.6	-0.5	7.1	7.6
Th/Dy	14	24.2	10.2	1.8	12	10.2

Th/Ho	**4.4**	**21.2**	**16.8**	**-7.3**	**9.5**	**16.8**
Th/Er	**16.8**	**26.4**	**9.6**	**1.8**	**11.5**	**9.7**
Th/Tm				**0**	**0.1**	**0.1**
Th/Hf				**-2.1**	**24.2**	**26.3**
Th/Os	**36.5**	**24.6**	**13.9**			
Maximum	**36.5**	**26.4**	**16.2**	**1.8**	**24.2**	**26.3**
Minimum	**0.9**	**3.8**	**-0.2**	**-7.3**	**-4.1**	**0.2**
Difference	**34.6**	**22.6**	**16**	**9.1**	**28.3**	**26.1**

(Hayek, 2009, Page 522)

The Metal-Poor Halo Star Bd+173248

This star was analysed in 2002 and found to contain osmium, platinum, and (for the first time in a metal-poor star) gold, elements whose abundances can only be reliably determined using HST. **(Cowan, 2002, Page 861)** Five dates older than the Big Bang were obtained.

Table 6

Dating Method	**Age (Ga)**	**Lower Limit**
Th/Eu	**10**	**8.2**
Th/Ir	**21.7**	**14.8**
Th/Pt	**10.3**	**16.8**
Th/U	**13.4**	**11**
U/Ir	**15.5**	**13.5**
U/Pt	**12.4**	**14.6**

(Cowan, 2002, Page 876)

There seems to be an endless set of unprovable assumptions in all calculations. "We caution, however, that all of these age estimates are very sensitive to uncertainties both in the theoretically predicted initial values and in the observations themselves; this is particularly true for our very weak detection of uranium. In addition, further investigation of any possible real offset between the rare earth elements and the third r-process peak elements and the corresponding effect on nucleo cosmo chronometry will be necessary." **(Cowan, 2002, Page 876)**

Uranium-Thorium Cosmo Chronology

There is an endless list of unprovable assumptions in the article.

1. "In this model, the proto–neutron star mass and the (asymptotic) neutrino sphere radius are assumed to be 2.0M_o and 10 km, respectively." **(Wanajo, 2002, Page 853)**

2. "The temperature and density histories of the material involved in the neutron capture processes are obtained with the assumption of a steady flow of the neutrino-powered winds, with general relativistic effects taken into account." **(Wanajo, 2002, Page 853)**

3. "The mass-integrated r-process yields, obtained by assuming a simple time evolution of the neutrino luminosity, are compared to the available spectroscopic elemental abundance data of CS 31082-001." **(Wanajo, 2002, Page 853)**

4. "In fact, the large dispersion of Eu/Fe observed in halo stars (more than 2 orders of magnitude) has been naturally explained by chemical evolution models that make such assumptions." **(Wanajo, 2002, Page 854)**

5. "Thus far, the initial production of Th/r has been determined by fitting theoretical nucleosynthesis results to the solar r-process pattern, with the assumption that the r-pattern was universal in all astrophysical environments." **(Wanajo, 2002, Page 854)**

6. "Therefore, any age estimates that demand assumption of the universality of the r-process pattern may in fact be unreliable." **(Wanajo, 2002, Page 854)**

7. "In addition to the above nonuniversality problem, the initial r-process pattern has thus far been determined theoretically by the superposition of nucleosynthesis results, where one is forced to assume constant temperatures, neutron number densities, and exposure times." **(Wanajo, 2002, Page 854)**

8. "These approximations have been necessary because of the lack of a reliable astrophysical model for the r-process site." **(Wanajo, 2002, Page 854)**

9. "The system is treated as time stationary and spherically symmetric, and the radius of the neutron star is assumed to be the same as that of the neutrino sphere." **(Wanajo, 2002, Page 855)**

10. "The neutrino luminosities, L, of all neutrino flavors are assumed to be equal." **(Wanajo, 2002, Page 855)**

11. "This assumption may be inadequate, as the physical conditions of the neutrino sphere and the outer boundary are not necessarily causally connected." **(Wanajo, 2002, Page 855)**

Table 7

Method	**Th/Eu**	**Th/Os**	**Th/Ir**	**U/Eu**	**U/Os**	**U/Ir**	**U/Th**
Age	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**
	18.77	**57.52**	**27.18**	**15.63**	**27.95**	**18.3**	**14.16**
	12.61	**46.73**	**16.09**	**13.62**	**24.47**	**14.73**	**14.1**
	5.17	**34.01**	**3.64**	**11.32**	**20.49**	**10.83**	**14.19**
	-16.9	**11.67**	**-17.55**	**3.97**	**13.05**	**3.76**	**13.7**
	-32.54	**-0.84**	**-29.64**	**-1.12**	**8.96**	**-0.2**	**13.53**
	-118.21	**-51.05**	**-76.97**	**-29.3**	**-7.94**	**-16.18**	**12.16**
Average	**-21.85**	**16.34**	**-12.875**	**2.35**	**14.50**	**5.21**	**13.64**
Maximum	**18.77**	**57.52**	**27.18**	**15.63**	**27.95**	**18.3**	**14.19**
Minimum	**-118.21**	**-51.05**	**-76.97**	**-29.3**	**-7.94**	**-16.18**	**12.16**
Difference	**136.98**	**108.57**	**104.15**	**44.93**	**35.89**	**34.48**	**2.03**

Table 7 contains 14 negative dates [red] and 15 dates [blue] older than the Big Bang explosion and a 175-billion-year age range. **(Wanajo, 2002, Page 863)** The data in table 8 is calculated from the age graph **(Wanajo, 2002, Page 863)** by the same author.

Table 8

Method	**Th/Eu**	**Th/Os**	**Th/Ir**	**U/Eu**	**U/Os**	**U/Ir**	**U/Th**
Age	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**	**(Ga)**
	-32.31	**-1.23**	**-29.85**	**-29.23**	**-8.00**	**-16.31**	**13.54**

	-16.62	11.38	-17.23	-0.92	8.62	0.31	13.54
	5.23	33.85	3.69	4.00	12.92	4.31	13.54
	12.31	46.46	16.00	12.00	20.62	11.08	13.54
	18.77	57.54	27.38	13.85	24.00	15.08	13.54
				16.31	27.69	18.46	13.54
Average	**-2.52**	**29.60**	**0.00**	**2.67**	**14.31**	**5.49**	**13.54**
Maximum	**18.77**	**57.54**	**27.38**	**16.31**	**27.69**	**18.46**	**13.54**
Minimum	**-32.31**	**-1.23**	**-29.85**	**-29.23**	**-8.00**	**-16.31**	**13.54**
Difference	**51.08**	**58.77**	**57.23**	**45.54**	**35.69**	**34.77**	**0**

Table 8 contains 9 negative dates and 13 dates older than the Big Bang explosion and a 90-billion-year age range. **(Wanajo, 2002, Page 863)**

Lead And Thorium In The Early Galaxy

Roederer's calculations are based on a long list of unproven assumptions listed below. The dates obtained [Table 9] have an impossible 24.8-billion-year range.

"This explicitly assumes that the four r-process standard stars contain no amount of s-process material." **(Roederer, 2009, page 1971)**

"These stellar ratios are compared with our predictions, made using the classical waiting-point assumption—defined as an equilibrium condition between neutron captures and photo disintegrations." **(Roederer, 2009, page 1973)**

"Although this approach makes the simplifying assumptions of constant neutron number density and temperature as well as instantaneous nuclear freezeout, the equilibrium model calculations reproduce the S.S. abundances well." **(Roederer, 2009, page 1973)**

"Our approach can be considered reliable only if we achieve a "consistent" picture—meaning that the abundances are solar—with logical astrophysical assumptions for the three heaviest r-process observables." **(Roederer, 2009, page 1973)**

"The specific calculations employed here assume a weighted range of neutron number densities (from 10^{23} to 10^{30} cm^{-3})." **(Roederer, 2009, page 1973)**

"We also assume a varying r-process path related to contour lines of constant neutron separation energies in the range of 4–2 MeV." **(Roederer, 2009, page 1973)**

"Assuming the stellar Pb abundances are not seriously in error, we currently lack a complete, self-consistent understanding of r-process nucleosynthesis and enrichment for all low metallicity stars." **(Roederer, 2009, page 1976)**

"The horizontal lines indicate the ratios expected if a sample of material had a given age, assuming the nucleosynthesis predictions of Kratz." **(Roederer, 2009, page 1977)**

"If we divide the sample into two groups of stars—those with an actinide boost and those without—and assume a single age for each group, we can derive reasonable estimates for the age of the r-process-only standard stars, as shown in Table 9." **(Roederer, 2009, page 1977)**

"Assuming that the observed stellar ratios are independent (which they clearly are not since all rely on Th), we derive an age for the ensemble of standard r-process-only stars of 15.2 ± 2.1 (σ = 4.6) Gyr." **(Roederer, 2009, page 1977)**

Table 9

Method	Age (Ga)	Age (Ga)	Difference
Th/La	**20.4**	**6.4**	**14**
Th/Eu	**10.6**	**-4.4**	**15**
Th/Er	**13.2**	**1.5**	**11.7**
Th/Hf	**19.7**	**3.4**	**16.3**
Th/Ir	**11.7**	**-2.3**	**14**
Th/Pb	**9.9**		

(Roederer, 2009, Page 1978)

Actinides: Their Stellar Production

Goriely's calculations are based on a long list of unproven assumptions listed below. The dates obtained [Table 10] have an impossible 21-billion-year range.

"The canonical model assumes that some stellar material composed solely of iron nuclei is subjected to neutron densities and temperatures that remain constant over the whole neutron irradiation time." **(Goriely, 2001, Page 1114)**

"This is even more true if different types of r-process episodes have to be considered, at least if the assumption of the "universality" of the r-process yields is not adopted from the start." **(Goriely, 2001, Page 1115)**

"The long-lived 232Th/238U and 235U/238U pairs have been classically used to estimate the age of the r-nuclides (assumed to be roughly equal to the age of the Galaxy) from the present meteoritic content of these nuclides." **(Goriely, 2001, Page 1117)**

"The major origin of the difficulty lies in the necessity to make the assumption that the r-process is universal." **(Goriely, 2001, Page 1118)**

"In these conditions, the universality assumption would lead to quite odd chronometric conclusions. In particular, the Th/Eu ratio in CS 31082-001 is about 3.2 times larger than in CS 22892-052. Hence, under the universality assumption, CS 22892-052 predates CS 31082-001 by 24 Gy, and would thus be about 36 Gy old." **(Goriely, 2001, Page 1118)**

"In these conditions, and if the universality of the Pb/Th ratio is assumed, the observed Pb/Th values turn out to be discrepant by a factor of about 10, at least if the two stars have roughly the same age. If this is indeed the case (which is not a farfetched assumption in view of their similar [Fe/H] ratio), either the universality assumption is invalid, and a specific actinide-producing r-process has to be called for, or the Pb in CS 22892-052 is largely of s-process origin." **(Goriely, 2001, Page 1118)**

"Even if the assumption of a universal r-process appears to be more and more fragile with time, we dare suppose in the following that it indeed holds in order to examine if constraints can be put in such a favorable situation on the nuclear and astrophysical models for use in r-process calculations, and consequently on the actinide production." **(Goriely, 2001, Page 1118)**

"This clearly contradicts the universality assumption which is the basis of all the chronometric considerations making use of metal-poor stars." **(Goriely, 2001, Page 1120)**

"Second, the constraints adopted to select the recommended actinide productions and their ranges of variations given in Tables 1 and 2, while admittedly highly subjective, appear reasonable to the authors only under the assumption of the universality of the r-process. At discussed above, this basic assumption appears to be more and more questionable as data accumulate. As a direct consequence, the derived constraints are increasingly unsecure." **(Goriely, 2001, Page 1120)**

"A single r-process production is assumed at time zero." **(Goriely, 2001, Page 1121)**

Seven Eu/U dates are over 16 billion years old. Six Eu/Th dates are over 16 billion years old.

Table 10

Case Number	U/Th Age (Ga)	U/Eu Age (Ga)	Case Number	U/Th Age (Ga)	U/Eu Age (Ga)
1	13.55	8.38	17	11.58	5.73
2	12.48	7.81	18	10.57	4.74
3	13.54	8.14	19	11.97	4.75
4	13.92	10.16	20	14.57	11.14
5	8.94	7.86	21	10.77	8.49
6	16.14	20.52	22	13.39	18.03
7	13.66	2.88	23	11.59	1.71
8	14.3	13.2	24	15.81	15.46
9	14.3	13.15	25	20.09	16.12
10	12.31	10.43	26	10.13	7.47
11	17.73	16.23	27	16.18	13.08
12	14.65	12.67	28	12.74	8.87
13	13.56	13.38	29	15.38	15.87
14	16.11	22.6	30	13.61	20.64
15	17.31	16.86	31	15.45	16.28
16	14.02	14.43	32	10.94	13.06

(Goriely, 2001, Page 1119)
Table 10 contains 27 dates older than the Big Bang explosion and a 20-billion-year age range. Lowest age is 1.71 Ga and the oldest is 22.6 Ga.

The halo giant CS 31082-001

(Hill, 2002)
“It is difficult to conceive any reasonable scenario that would account for this by an age difference: CS 22892-052 and HD115444 would then be 20 and 18 Giga years older than CS 31082-001, respectively (regardless of the adopted production ratio for Th/Eu), which seems unrealistic.” **(Hill, 2002, Page 573)**

“Using the same initial production ratio as in Cayrel, this leads to an age of almost 17 Ga, 4.3 Ga greater than that originally published. By contrast, use of the conventional Th/Eu chronometer leads instead to a slightly negative (!), or at most a T-Tauri like age for CS 31082-001.” **(Hill, 2002, Page 574)**

The Thorium Chronometer

(Cowan, 1997)
Table 11

Source	Th/Eu	Age(Ga)	Error
Solar system:	0.463	15.2	3.7
Theory 1:	0.479	15.9	2
No Fission	0.499	16.7	2
Less consistent	0.502	16.8	2
Theory 2	0.427	13.5	2

(Cowan, 1997, Page 248)

Several quotes from this article give absurd ages:

“These Galactic chemical evolution models suggest an age of 17 Ga for CS 22892-052.” **(Cowan, 1997, Page 246)**

“This function is plotted in Figure 8 for disk ages, t_d, of 8, 10.5, and 15 Ga, and an age for the solar material, t of 4.6 Ga; the implied age estimate, of 18.1 +/- 4 Ga, from the observed N(Th/Eu) in CS 22892-052 is indicated on the figure; if the ratio of Th to all r-process elements is used an age of 16.3 Ga results.” **(Cowan, 1997, Page 252)**

“Age dependence of the observed Th/r ratio (in units of the observed solar system value), based on a simple model of chemical evolution and three different assumed ages for the Galactic disk. Galactic disk ages of 8, 10.5, and 15 Ga are indicated. The horizontal lines represent the observed Th/r ratio in CS 22892-052 with 1 p uncertainty; the best-fit age is 18 Ga, with an acceptable range from 14 to 22 Ga.” **(Cowan, 1997, Page 252)**

“In this circumstance the most likely age of the CS 22892-052 material is 17-18 Ga.” **(Cowan, 1997, Page 253)**

“Our Galactic evolution models therefore suggest an age of 17 Gyr for CS 22892-052, with an inferred disk age of 10.5 Gyr.” **(Cowan, 1997, Page 253)**

Chronometers In Metal-Poor Stars

Several quotes from this article admit that unprovable assumptions underly his calculations:

“These theoretical computations assume the classical waiting point approximation of (n, c) ¢ (c, n) equilibrium.” **(Cowan, 1999, page 194)**

“We assume, as a working hypothesis, that the heavy element abundances of very low metallicity stars are given by a pure r-process composition. This assumption is supported by the observational evidence, at least for the elements beyond Ba, for which data are available. We have analyzed r-process abundances with predictions from calculations in the waiting-point assumption.” **(Cowan, 1999, page 196)**

“The major remaining question is related to the assumption of an (n, c) ¢ (c, n) equilibrium during the freeze-out phase in realistic astrophysical sites and depends on the temporal decline pattern of neutron density and temperature below the above-mentioned limits.” **(Cowan, 1999, page 196)**

“However, the disadvantage is that these highly advanced and computationally expensive calculations still assume spherical symmetry for all nuclei.” **(Cowan, 1999, page 198)**

“Applying them in Galactic evolution models, which include assumptions about the histories of star formation rates and r-process production” **(Cowan, 1999, page 200)**

“The major remaining contamination of the Th II feature is due to Co I (chiefly at 4019.3 Angstroms), and we altered the assumed Co abundance to match this absorption.” **(Cowan, 1999, page 201)**

One of the dates calculated is over 40 billion years old.

Table 12

Model	^{90}Th	^{63}Eu	Th/Eu	Age (Ga)
Solar	0.042	0.09	0.463	13.8
FRDM	0.0428	0.0242	1.7695	41.0
ETFSI-1	0.02949	0.06041	0.4881	14.9

HFB/SkP	**0.01991**	**0.05134**	**0.3879**	**10.2**
FRDM-HFB	**0.03449**	**0.06958**	**0.4957**	**15.2**
ETFSI-Q	**0.06292**	**0.11533**	**0.5456**	**17.1**
ETFSI-Q(lsq)	**0.04222**	**0.08788**	**0.4804**	**14.5**

(Cowan, 1999, Page 202)

"This led to the exclusion of the mass models of Hilf, FRDM, and ETFSI-1. FRDM is listed in Table 3, but the Eu abundance prediction is off by a factor of more than 3, underlining the previous finding and therefore making the age prediction meaningless." **(Cowan, 1999, Page 203)**

Thorium Ages For Metal-Poor Stars

Several quotes from Johnson's article admit that unprovable assumptions underly her calculations:

"We obtain an average age of 11.4 Gyr, which depends critically on the assumption of an initial Th/Eu production ratio of 0.496. If the universe is 15 Gyr old, then the (Th/Eu) should be 0.590, in agreement with some theoretical models of the r-process." **(Johnson, 2001, page 888)**

"A second significant source of uncertainty in the Th-based ages is the assumption that the r-process abundance pattern for elements from Ba to Th is universal and that the abundance of elements such as Ba, Eu, Nd, and Sm can be used to estimate the initial Th abundance in a star." **(Johnson, 2001, page 888)**

"For the rest of our analysis, we assume that the heavy-element abundances in our sample of stars represent contributions from the r-process only." **(Johnson, 2001, page 899)**

"We are assuming that the metal enrichment for these metal-poor stars happened over a short period of time, so we do not need to model Galactic chemical history)." **(Johnson, 2001, page 900)**

"Our mean age is based on the assumption of a universal r-process pattern." **(Johnson, 2001, page 901)**

"If we assume that all the metal-poor stars for which we have measured Th are coeval, we can put a limit on the observed dispersion in the initial Th/Eu ratio. Table 7 gives this value assuming that all the stars are 12 Gyr old." **(Johnson, 2001, page 901)**

"They found an average age of 14.5 Gyr, again close to ages derived for the MSTO, assuming (Th/Eu) = 0.496 as in this paper." **(Johnson, 2001, page 888)**

Table 13

Star	**Age (Ga)**	**Age (Ga)**	**Age (Ga)**	**Age (Ga)**
HD 186478	**16.8**	**16.8**	**18.3**	**18.3**
HD 115444	**4.2**	**9.8**	**6.1**	**11.2**
HD 108577	**9.3**	**8.4**	**10.6**	**9.8**
BD 82548	**9.3**	**7.5**	**10.8**	**8.9**
M92 VII-18	**6.5**	**7.5**	**7.9**	**8.8**

(Johnson, 2001, Page 900)

Table 14

Stars	**Age (Ga)**	**Age (Ga)**	**Age (Ga)**
Name	**Maximum**	**Minimum**	**Difference**
HD 186478	**22.5**	**14.14**	**8.36**
HD 115444	**15.42**	**3.00**	**12.42**
HD 108577	**14.54**	**5.63**	**8.91**
BD 82548	**14.78**	**4.67**	**10.11**
M92 VII-18	**14.46**	**3.00**	**11.46**

(Johnson, 2001, Page 901)

Neutron Capture–Rich Star CS 22892-052

"Thorium is radioactive with a half-life of 14.0 Gyr, and the observed [Th/Eu] abundance ratio combined with an assumed extrapolation of the solar system r-process abundance distribution out to Th yielded a simple 'decay age' of about 15 Gyr." **(Sneden, 2003, page 937)**

"Assuming that CS 22892-052 began its life with a 'Spite plateau' Li abundance of log 2.0." **(Sneden, 2003, page 942)**

"Both of these effects must be carefully accounted for in synthetic spectrum computations, and still the derived abundances from such deep and saturated absorption features are dependent on assumed values of microturbulent velocity." **(Sneden, 2003, page 945)**

"This distribution, indicated by the solid line, is based on n-capture cross section measurements and assumes the ''classical'' s-process empirical relation between abundance and cross section." **(Sneden, 2003, page 946)**

"We proceed now on the assumption that the robustness in the heavy region continues through the actinides, so that we can utilize abundance data concerning the interesting actinide radioactivity 232 Th, 235 U, and 238 U to date the star." **(Sneden, 2003, page 948)**

"These chronometric age estimates, however, depend sensitively on the predicted initial values of the radioactive elements, in ratio to each other, or to stable elements. To determine these initial ratio values, we have utilized the theoretical r-process predictions described in 4.2." **(Sneden, 2003, page 948)**

"An average of the chronometer pairs, assuming initial solar system ratios, gives an age of 14.7 Gyr, which is not inconsistent with the average based on theoretically predicted r-process abundance ratios." **(Sneden, 2003, page 949)**

Table 15

Dating	**Average**	**Lower Limit**
Method	**Age (Ga)**	**Age (Ga)**
Th/Eu	**12.8**	**13.2**
Th/Ir	**19.2**	**13.1**
Th/Pt	**10.5**	**17.7**
Th/U	**10.4**	

(Sneden, 2003, Page 949)

The R-Process In Supernova Explosions

(Wanajo, 2003)

Table 16

Th/Eu	**U/Th**	**Difference**	**Th/Eu**	**U/Th**	**Difference**

Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)
-2.50	7.72	10.22	23.37	14.75	8.62
4.00	9.51	5.51	23.11	14.75	8.36
6.72	13.09	6.37	21.71	14.75	6.97
8.51	13.95	5.44	20.32	14.75	5.57
10.04	14.75	4.71	18.60	14.75	3.85
11.36	14.75	3.38	16.74	14.75	1.99
12.56	14.75	2.19	15.08	14.75	0.33
13.55	14.75	1.19	13.36	14.75	1.39
14.35	14.75	0.40	11.96	14.75	2.79
15.41	14.75	0.66	10.57	14.75	4.18
16.54	14.75	1.79	8.98	14.75	5.77
17.53	14.75	2.79	7.78	14.75	6.97
19.19	14.75	4.44	6.39	14.75	8.36
20.72	14.75	5.97	5.53	14.75	9.22
23.37	14.75	8.62	4.47	14.75	10.28

(Wanajo, 2003, Page 977)

"The age Th/Eu is sensitive to the parameter M, ranging from a negative age to 23.8 Gyr, which illustrates that caution must be used in the application of this chronometer pair."
(Wanajo, 2003, Page 977)

Table 16 contains 1 negative date and 41 dates older than the Big Bang explosion and a 26-billion-year age range.

Accuracy of Radioactive Dating of Stars

(Ludwig, 2010)
Table 17 (Part A)

Isotope	Object	Th/Eu	Th/Hf	Th/Os	Th/Ir	Max	Min
Ratios	Name	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]
Th/Eu	BD+173248	7.6	6.3	8.3	10.5	10.5	6.3
Th/Ir		20.7	14	19.1		20.7	14
Th/Os		27.7	22			27.7	22
Th/Eu	BD+82856	7.3	5.8	8	9.6	9.6	5.8
Th/Eu	CS22892-052	14.8	13.4	15.4	17.6	17.6	13.4
Th/Eu		15.4	13.1	15	17.3	17.3	13.1
Th/Eu		12.1	11.7	13.7	15.9	15.9	11.7
Th/Hf		27.7				27.7	27.7
Th/Hf		24.6				24.6	24.6
Th/Ir		25.8	19.1	25.2		25.8	19.1
Th/Ir		19	13.3	19.4		19.4	13.3
Th/Os		19.6	14.8			19.6	14.8
Th/Os		24.4	18.6			24.4	18.6
Th/Os		26	20.3			26	20.3
Th/Eu	CS31082-001	0.9	-1.5	0.5	2.7	2.7	-1.5
Th/Hf		15.2				15.2	15.2
Th/Ir		6.5	-0.2	5.9		6.5	-0.2
Th/Os		17.9	12.1			17.9	12.1
U/Th		16.6	13.3	14.6		16.6	13.3
Th/Eu	HD108577	7.8	6.2	8.4	10.1	10.1	6.2
Th/Eu	HD115444	11.7	10.4	12.3	14.6	14.6	10.4
Th/Eu		9.6	8.1	10.3	11.9	11.9	8.1
Th/Os		30.1	24.3			30.1	24.3
Th/Eu	HD186478	16.6	15.1	17.3	18.9	18.9	15.1
Th/Eu	HD221170	11.7	10.4	12.3	14.6	14.6	10.4
Th/Hf		21.9				21.9	21.9
Th/Ir		20.7	14	19.1		20.7	14
Th/Os		27.1	22.3			27.1	22.3

(Ludwig, 2010, Page 5)

Table 17 (Part B)

Isotope	Object	Th/Eu	Th/Hf	Th/Os	Th/Ir	Max	Min
Ratios	Name	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]
Th/Eu	HE1523-0901	11.4	9.5	11	13.2	13.2	9.5
Th/Ir		18	12.3	17.4		18	12.3
Th/Os		16.9	10.1			16.9	10.1
U/Th		15				15	15
Th/Hf	M4-L1411	32.5				32.5	32.5
Th/Hf		32.5				32.5	32.5
Th/Hf	M4-L1501	25.5				25.5	25.5
Th/Hf	M4-L1514	37.2				37.2	37.2
Th/Hf	M4-L2406	32.5				32.5	32.5
Th/Hf	M4-L2617	23.2				23.2	23.2
Th/Hf	M4-L3209	30.2				30.2	30.2
Th/Hf	M4-L3413	23.2				23.2	23.2

Th/Hf	**M4-L4511**	**27.8**				**27.8**	**27.8**
Th/Hf		**37.2**				**37.2**	**37.2**
Th/Eu	**M51-K341**	**11**	**9.7**	**12.6**	**13.9**	**13.9**	**9.7**
Th/Eu	**M51-K462**	**14.1**	**12.7**	**14.7**	**16.9**	**16.9**	**12.7**
Th/Eu	**M51-K583**	**6.6**	**4.3**	**7.2**	**8.5**	**8.5**	**4.3**
Th/Hf	**M5-IV-81**	**18.5**				**18.5**	**18.5**
Th/Hf	**M5-IV-82**	**18.5**				**18.5**	**18.5**
Th/Eu	**M92-VII-18**	**6.8**	**5.3**	**7.5**	**9.1**	**9.1**	**5.3**
Th/Eu	**Sun**	**3.3**	**1.7**	**3.9**	**5.6**	**5.6**	**1.7**
Th/Hf		**22.3**				**22.3**	**22.3**
Th/Ir		**10.1**	**4**	**9.6**		**10.1**	**4**
Th/Os		**14.1**	**8.6**			**14.1**	**8.6**

(Ludwig, 2010, Page 5)

Table 17 contains 36 dates older than the Big Bang explosion and a 39-billion-year age range.

Table 18

Object Name	**Max [Gyr]**	**Min [Gyr]**	**Difference [Gyr]**
BD+173248	**27.7**	**6.3**	**21.4**
BD+82856	**9.6**	**5.8**	**3.8**
CS22892-052	**27.7**	**11.7**	**16**
CS31082-001	**17.9**	**-1.5**	**19.4**
HD108577	**10.1**	**6.2**	**3.9**
HD115444	**30.1**	**8.1**	**22**
HD186478	**18.9**	**15.1**	**3.8**
HD221170	**27.1**	**10.4**	**16.7**
HE1523-0901	**17.4**	**9.5**	**7.9**
M4-L1411	**32.5**		
M4-L1501	**25.5**		
M4-L1514	**37.2**		
M4-L2406	**32.5**		
M4-L2617	**23.2**		
M4-L3209	**30.2**		
M4-L3413	**23.2**		
M4-L4511	**37.2**		
M51-K341	**13.9**	**9.7**	**4.2**
M51-K462	**16.9**	**12.7**	**4.2**
M51-K583	**8.5**	**6.6**	**1.9**
M5-IV-81	**18.5**		
M5-IV-82	**18.5**		
M92-VII-18	**9.1**	**5.3**	**3.8**
Sun	**22.3**	**1.7**	**20.6**

A summary of table 17.

Figure 1.

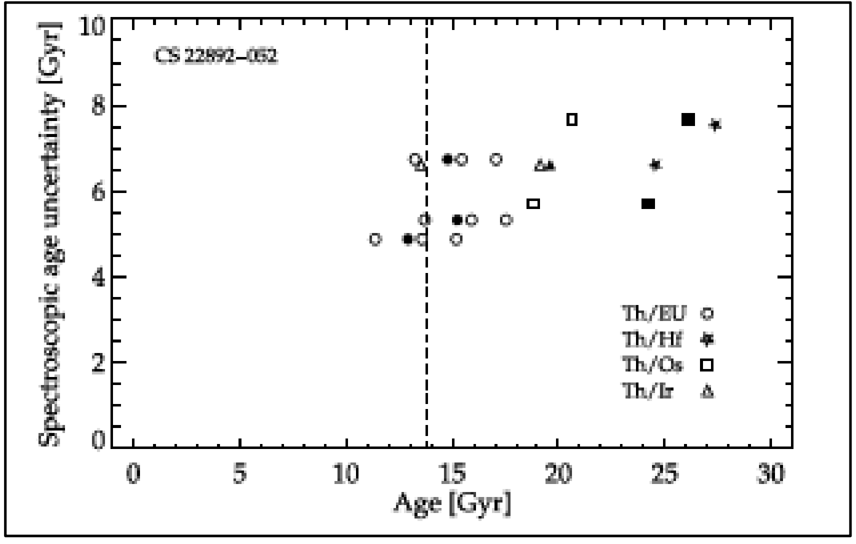

Figure 1. Ages and spectroscopic age uncertainties for star CS 22892-052 determined from various chronometer pairs (symbols) assuming up to four different production ratios. Filled symbols refer to the production rations of Kratz. The dashed line indicates the age of the universe. Sneden give a radio chronometric age estimate of 14.2 ± 3 Gyr for this star. **(Ludwig, 2010, Page 5)**

Gyro Chronological and isochronal age estimates

(Maxted, 2015)

Table 21

Stars Name	**Isochrone Age (Gyr)**	**Gyrochronology Age (Gyr)**	**Tidal Age Billion Years**	**Tidal Age Trillion Years**
55-Cnc	**10.91**	**8.1**	**6,310**	**6.310**
CoRoT-2	**2.66**	**0.17**	**20**	**0.020**
CoRoT-4	**2.1**	**1.81**	**199,526**	**200**
CoRoT-6	**3.4**	**0.35**	**10,000**	**10**
CoRoT-7	**2.92**	**2.8**	**12,589**	**12.589**

CoRoT-13	5.99	2.34	794	0.794
CoRoT-18	10.69	0.22	16	0.016
HAT-P-11	0.72	3.89	5,011,872	5,012
HAT-P-21	9.52	1.64	126	0.126
HATS-2	9.7	3.1	32	0.032
HD-189733	4.75	0.71	794	0.794
HD-209458	2.42	1.83	3,162	3.162
Kepler-17	1.48	1.43	20	0.020
Kepler-30	4.38	1.47	10,000,000,000	10,000,000
Kepler-63	3.16	0.23	6,309,573	6,310
Qatar-2	15.72	0.64	16	0.016
WASP-4	6.27	2.72	40	0.040
WASP-5	5.84	2.13	32	0.032
WASP-10	6	0.66	398	0.398
WASP-19	9.95	0.89	3	0.003
WASP-41	8.25	1.71	1,995	2
WASP-46	10.03	1.23	20	0.020
WASP-50	8.57	1.3	158	0.158
WASP-69	15.2	2.09	79,433	79.433
WASP-77	7.57	1.35	20	0.020
WASP-84	1.89	0.99	501,187	501
WASP-85	2.09	1.5	1,000	1.000
WASP-89	12.07	1.88	79	0.079

Table 21 contains 28 dates [blue] older than the Big Bang explosion and a ten million trillion-year age range. Purple squares are twelve dates > one trillion years old.

Analysis of very metal-poor r-I stars

(Mello, 2014)

Table 22

Dating Method	CS 31082-001 Age (Gyr)	CS 30315-029 Age (Gyr)	Dating Method	CS 31082-001 Age (Gyr)	CS 30315-029 Age (Gyr)
Th/La	-11.21	-10.01	Th/Gd	-1.87	-9.81
	16.35	17.55		55.57	47.63
	22.42	23.62		18.68	10.74
Range	33.63	33.63	Range	57.44	57.44
Th/Ce	-4.67	0.25	Th/Tb	-7.01	-3.27
	35.03	39.94		32.69	36.43
	20.55	25.47		21.02	24.75
Range	39.70	39.70	Range	39.70	39.70
Th/Pr	-5.14	1.03	Th/Dy	0.93	-2.8
	36.89	43.06		39.23	35.49
	20.55	26.71		36.43	32.69
Range	50.03	42.03	Range	38.30	38.30
Th/Nd	-3.74	-0.86	Th/Er	0	0.93
	26.62	29.5		30.82	31.76
	7.01	9.88		18.68	19.61
Range	30.35	30.35	Range	30.82	30.83
Th/Sm	-1.87	4.2	Th/Tm	-2.34	-6.77
	26.62	32.69		22.42	17.98
	13.54	19.61		12.61	8.17
Range	28.49	28.49	Range	24.76	24.76
Th/Eu	-2.8	-5.32			
	-1.4	-3.92			
	-3.27	-5.79			
	14.48	11.96			
	-5.14	-7.66			
	35.03	32.5			
	15.41	12.89			
Range	40.17	39.17			

Negative dates [Red] and dates [Blue] older than the Big Bang. Table 22 contains 9 negative dates and 22 dates older than the Big Bang explosion and a 67-billion-year age range.

Chromospherically young, Kinematically old stars

(Rocha-Pinto, 2002)

Table 23

Chromosphere Age (Ga)	Isochrone Age (Ga)	Age Difference	Age Ratio
0.28	1.3	1.02	4.64
0.5	1.8	1.3	3.60
2.07	2	0.07	0.97
0.38	2.3	1.92	6.05
4.7	2.6	2.1	1.81
6.43	7.4	0.97	1.15

1.14	8.5	7.36	7.46
0.49	8.7	8.21	17.76
2.53	10	7.47	3.95
5.39	13	7.61	2.41
4.16	13.8	9.64	3.32
7.91	18	10.09	2.28
3.92	18.9	14.98	4.82

Table 23 contains 3 dates older than the Big Bang explosion and an 18-billion-year age range.

Pulsars in globular clusters

(Freire, 2015)

A radio pulsar's characteristic age τ (seconds) is usually defined as:

$$\tau = \frac{P}{2\dot{P}} = \frac{P}{2dP/dt}$$

Where *P* is the pulsar's period, and the dot represents the period derivative (the rate the pulsar is slowing).

Table 24

Cluster	Pulsar	Million Years	Billion Years	Trillion Years
47 Tucanae	J0024-7204Q	18,784	19	
	J0024-7204T	40,937	41	
	J0024-7203U	72,255	72	
	J0024-7201X	4,117,455	4,117	4.117
M3	J1342+2822B	2,037,213	2,037	2.037
M13	J1641+3627E	22,516	23	
M92	J1717+4308A	818,942	819	0.819
NGC 6342	B1718-19(A)	1,000,506,531	1,000,507	1,000.507
M14	J1737-0314A	328,491	328	0.328
Terzan 5	J1748-2446D	574,527	575	0.575
	J1748-2446F	21,944,555	21,945	21.945
	J1748-2446G	880,437	880	0.880
	J1748-2446J	509,151	509	0.509
	J1748-2446M	115,421	115	0.115
	J1748-2446N	249,670	250	0.250
	J1748-2446P	105,340	105	0.105
	J1748-2446R	169,516	170	0.170
	J1748-2446S	1,514,255	1,514	1.514
	J1748-2446T	362,108	362	0.362
	J1748-2446U	173,711	174	0.174
	J1748-2446W	555,225	555	0.555
	J1748-2446X	805,431	805	0.805
	J1748-2446Y	216,341	216	0.216
	J1748-2446ab	193,136	193	0.193
	J1748-2446ac	350,423	350	0.350
	J1748-2446ag	5,872,899	5,873	5.873
	J1748-2446ah	138,014	138	0.138
	J1748-2446ai	240,245	240	0.240
NGC 6440	B1745-20	1,145,077,656	1,145,078	1,145.078
NGC 6517	J1801-0857H	24,834	25	
NGC 6522	J1803-3002A	281,287	281	0.281
NGC 6624	B1820-30B	19,042,830,625	19,042,831	19,042.831
	J1823-3021C	2,871,266,125	2,871,266	2,871.266
M28	J1824-2452D	1,288,101,892	1,288,102	1,288.102
M22	J1836-2354A	22,928	23	
M71	J1953+1846A	1,596,719	1,597	1.597
M15	B2127+11H	223,117	223	0.223

Millisecond pulsars in 47 Tucanae

(Freire, 2001)

Table 25

Pulsar	Age (Ga)	Pulsar	Age (Ga)
H	-31,379	L	-565
D	-25,484	T	408
J	-3,401	E	569
N	-2,213	F	644
C	-1,830	U	722
M	-1,520	O	1,381
G	-1,519	Q	1,873

http://mnras.oxfordjournals.org/content/326/3/901.full.pdf

CSIRO Pulsar Catalogue

Table 26

Pulsar ID Number	Age 1 Million Years	Pulsar ID Number	Age 2 Million Years
J1603-7202	15,000	J1832-0836	-219,000
J2017-1614	15,000	J1125+7819	-201,000
J1745+1017	15,400	J1405-4656	-125,000
J2010+3051	15,700	J1946+3417	-84,300
J1946+3417	16,100	J1721-2457	-31,700
J1017-7156	16,700	J1417-4402	-30,800
J1904+0451	16,900	J0514-4002A	-21,600
J2010-1323	17,200	J2010+3051	-20,000
J1910-5959A	17,600	J1906+0454	-18,100
J1640+2224	17,800	B0021-72D	-17,600
J1938+6604	18,100	B0021-72H	-16,600
J1821+0155	18,500	J1843-1448	-15,700
J0931-1902	20,200	J0024-7204Z	-14,400
J1709+2313	20,200	J1813-2621	-14,200
J2317+1439	22,500	J2129-0429	-13,900
J1836-2354A	22,900	J1622-0315	-10,300
J1327-0755	23,900	J1801-3210	-5,760
J1518+4904	23,900	B0021-72J	-3,090
J0645+5158	28,500	J1641+8049	-2,420
J1618-4624	30,300	J1024-0719	-2,270
J2229+2643	31,100	B0021-72N	-2,060
J2055+3829	33,100	B0021-72C	-1,750
J1216-6410	34,700	B0021-72G	-1,470
J1910-5959C	38,700	B0021-72M	-1,470
J1101-6424	45,000	B0021-72I	-1,170
J1938+2012	55,600	J0024-7204Y	-968
J2322-2650	94,100	B0021-72L	-559
J0514-4002A	113,000	J0024-7204W	-425
		J0024-7204S	-369
		J1142+0119	-286
		B2127+11A	-83
		J1327-0755	-27

http://www.atnf.csiro.au/people/pulsar/psrcat/

Millisecond Pulsar Ages

(Kiziltan, 2010)

Table 27

Pulsar	τc(Ga)	τci(Ga)	τ(Ga)	τi(Ga)	τc/τ	Max	Min	Diff.
J0034−0534	6	55.71	4.29	39.9	0.15	55.71	4.29	51.42
J1709+2313	20.21	49.45	19.27	47.15	0.43	49.45	19.27	30.18
J1730−2304	6.37	42.92	6.24	42.27	0.15	42.92	6.24	36.68
J2317+1439	22.55	36.18	20.65	33.13	0.68	36.18	20.65	15.53
J1905+0400	12.34	33.12	11.47	30.81	0.4	33.12	11.47	21.65
J1640+2224	17.71	30.59	15.94	27.53	0.64	30.59	15.94	14.65
J1518+4904	23.84	29.34	23.74	29.23	0.82	29.34	23.74	5.6
J2019+2425	8.88	24.34	8.31	22.77	0.39	24.34	8.31	16.03
J2322+2057	7.85	18.49	7.51	17.69	0.44	18.49	7.51	10.98
J1629−6902	9.51	18.16	9.24	17.66	0.54	18.16	9.24	8.92
J1603−7202	14.98	17.94	14.85	17.81	0.84	17.94	14.85	3.09
J0610−2100	4.93	17.92	4.6	16.72	0.3	17.92	4.6	13.32
J2010−1323	17.17	1.5	16.54	1.8	0.1	17.17	1.5	15.67
J1909−3744	3.34	17.08	2.95	15.12	0.22	17.08	2.95	14.13
J1125−6014	10.39	16.37	8.89	14	0.74	16.37	8.89	7.48
J1721−2457	9.39	15.93	8.62	14.62	0.64	15.93	8.62	7.31
J2033+17	8.57	14.86	8.33	14.44	0.59	14.86	8.33	6.53
B1257+12	0.86	14.58	0.75	14.21	0.06	14.58	0.75	13.83

Kiziltan, Bulent, 2010, Millisecond Pulsar Ages, 2010, The Astrophysical Journal, 715:335–341

Obliquities Of Hot Jupiter Host Stars

(Albrecht, 2012)

Table 28

No.	Million Years	Billion Years	Trillion Years	No.	Million Years	Billion Years	Trillion Years
1	13,273.03	13.27	0.01	24	15,957,689.28	15,957.69	15.96

2	**20,652.38**	**20.65**	**0.02**	**25**	**14,824,156.95**	**14,824.16**	**14.82**
3	**25,291.23**	**25.29**	**0.03**	**26**	**22,231,563.37**	**22,231.56**	**22.23**
4	**30,972.05**	**30.97**	**0.03**	**27**	**20,275,426.77**	**20,275.43**	**20.28**
5	**31,547.87**	**31.55**	**0.03**	**28**	**35,234,653.45**	**35,234.65**	**35.23**
6	**91,826.92**	**91.83**	**0.09**	**29**	**49,087,397.15**	**49,087.40**	**49.09**
7	**135,197.92**	**135.20**	**0.14**	**30**	**64,709,792.07**	**64,709.79**	**64.71**
8	**142,879.53**	**142.88**	**0.14**	**31**	**935,341,070.18**	**935,341.07**	**935.34**
9	**214,274.26**	**214.27**	**0.21**	**32**	**1,686,436,543.29**	**1,686,436.54**	**1,686.44**
10	**239,315.05**	**239.32**	**0.24**	**33**	**3,723,659,869.53**	**3,723,659.87**	**3,723.66**
11	**248,296.16**	**248.30**	**0.25**	**34**	**7,498,424,177.51**	**7,498,424.18**	**7,498.42**
12	**298,517.64**	**298.52**	**0.30**	**35**	**11,667,290,311.41**	**11,667,290.31**	**11,667.29**
13	**439,511.26**	**439.51**	**0.44**	**36**	**14,824,156,947.62**	**14,824,156.95**	**14,824.16**
14	**635,287.05**	**635.29**	**0.64**	**37**	**16,556,556,074.13**	**16,556,556.07**	**16,556.56**
15	**1,303,076.77**	**1,303.08**	**1.30**	**38**	**25,761,432,229.09**	**25,761,432.23**	**25,761.43**
16	**1,566,642.86**	**1,566.64**	**1.57**	**39**	**33,340,338,460.68**	**33,340,338.46**	**33,340.34**
17	**1,749,725.84**	**1,749.73**	**1.75**	**40**	**30,406,750,063.94**	**30,406,750.06**	**30,406.75**
18	**1,883,518.99**	**1,883.52**	**1.88**	**41**	**74,984,241,775.12**	**74,984,241.78**	**74,984.24**
19	**2,437,642.45**	**2,437.64**	**2.44**	**42**	**80,717,927,841.32**	**80,717,927.84**	**80,717.93**
20	**2,930,690.82**	**2,930.69**	**2.93**	**43**	**102,558,108,941.28**	**102,558,108.94**	**102,558.11**
21	**3,213,438.59**	**3,213.44**	**3.21**	**44**	**159,576,892,755.04**	**159,576,892.76**	**159,576.89**
22	**4,908,739.72**	**4,908.74**	**4.91**	**45**	**339,601,816,308.59**	**339,601,816.31**	**339,601.82**
23	**12,105,145.23**	**12,105.15**	**12.11**				

Conclusion

The star CS31082-001 has an age between 10 to 14 billion years old. **(Cayrel, 2001, Page 692)**

For these abundance ratios and our production ratio $(Th/U)_0$ = 1.557, the ages for the two halo stars CS 31082_001 and BD +173248 are, respectively, 16.2 and 14.9 Ga, both having uncertainties of approximately 3.5 Ga arising from observational uncertainties. **(Kratz, 2007, Page 50)**

Comparing these predicted ratios with the weighted mean M15 value given above leads to age estimates ranging from 13.2 to 15.8 Ga, with an average value of 14.3 Ga. The age estimates resulting from the theoretical predictions have an uncertainty on the order of 3 Ga. **(Sneden, 2000a, Page 88)**

From the observed Th abundance, an average age of 16 Ga is derived for CS 228922052, consistent with the lower age limit of 11 Ga derived from the upper limit on the U abundance. **(Sneden, 2000b, Page 139)**

Comparing these initial values with the observed stellar ratio yields values of 13.7, 15.7, and 13.1 Ga, with an average age for HD 115444 of 14.2 Ga. **(Westin, 2000, Page 798)**

Table 29

Reference	Max (B.Y.)	Min (B.Y.)	Difference
(Albrecht, 2012)	**339,601,816**	**13**	**339,601,803**
(Barnes, 2007)	**20**	**0.164**	**20**
(Brown, 2014)	**28.84**	**3.15**	**26**
(Cowan, 1997)	**16.8**	**13.5**	**3**
(Cowan, 1999)	**41**	**10.2**	**31**
(Cowan, 2002)	**21.7**	**8.2**	**14**
(CSIRO, 2015)	**113**	**-219**	**332**
(Freire, 2001)	**1,873**	**-31,379**	**33,252**
(Freire, 2015)	**67,524**	**-106,470**	**173,994**
(Goriely, 2001)	**22.6**	**1.71**	**21**
(Hayek, 2009)	**36.5**	**-7.3**	**44**
(Johnson, 2001)	**22.5**	**3**	**20**
(Kiziltan, 2010)	**55.71**	**0.75**	**55**
(Krauss, 2003)	**20**	**15.4**	**5**
(Ludwig, 2010)	**37.2**	**-1.5**	**39**
(Maxted, 2015)	**10,000,000,000**	**0.17**	**10,000,000,000**
(Mello, 2014)	**55.57**	**-9.81**	**65**
(Rocha-Pinto, 2002)	**18.9**	**0.28**	**19**
(Roederer, 2009)	**20.4**	**-4.4**	**25**
(Schatz, 2002)	**50**	**-10**	**60**
(Sneden, 2003)	**19.3**	**10.4**	**9**
(Wanajo, 2002)	**57.52**	**-118.21**	**176**
(Wanajo, 2003)	**23.37**	**-2.5**	**26**
Totals	**10,000,000,000**	**-106,470**	**10,000,106,470**

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